Grove Well Output Calculator

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In the Spring 2024 issue of *From the Grove* there was an article titled, "Do You Have Enough Water to Grow Avocados?" written by Tim Spann. Fast forward almost two years when Tim was contacted by David Shea in late 2025. David is a retired FBI Agent and an aspiring California avocado grower. David had stumbled across the above-mentioned article as well as others in the CAC archives and had questions. Tim and David have been communicating ever since.

David is not someone to jump into something without doing his due diligence. He understands that avocado production is fraught with risk and he wants to be as well-prepared as possible before going into business with Mother Nature. As you may imagine, "preparing" for someone with David's background involves spreadsheets. Tim was never really a big fan of spreadsheets until he began farming for himself in 2020 and he now understands they can be an extremely valuable tool for farming.

As part of his preparation for becoming an avocado grower, David wanted to be certain he would have enough water on any property he purchases. He took the information from the Spring 2024 article along with other information available online and brought in Claude to help build a spreadsheet. Claude is the AI bot from the company Anthropic. David shared the resulting spreadsheet, Avocado Grove Well Output Calculator, with Tim and offered to share it if Tim found value in it. Tim was impressed. It is worth sharing.

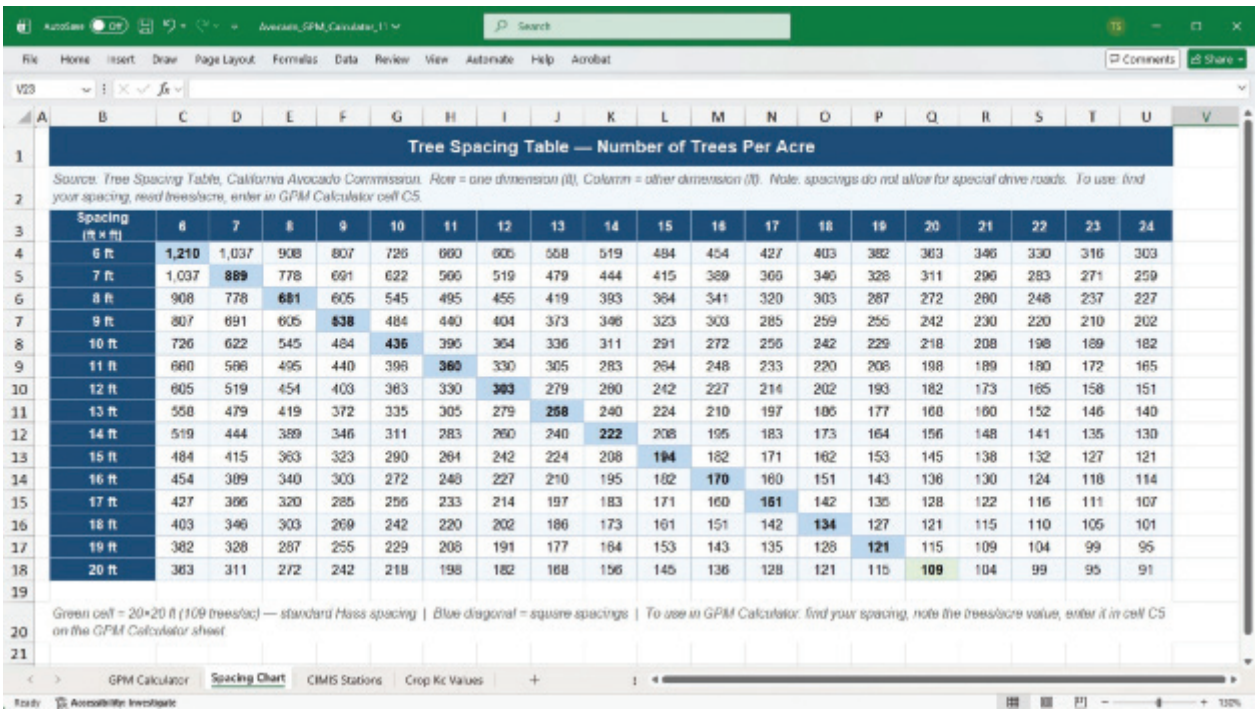
The Spreadsheet

We are going to assume that you have a rudimentary knowledge of spreadsheets for the purposes of this article. The current version of the spreadsheet (Avocado_GPM_Calculator_v.16) is available for download on the CAC website here: *californiaavocadogrowers.com/GPM-calculator.* Currently the spreadsheet is only available in Microsoft Excel.

The spreadsheet is composed of four pages. Each page is accessible by the tabs at the bottom of the Excel window. The pages are GPM Calculator, Spacing Chart, CIMIS Stations and Crop K_c Values **(Figure 1)**. Most of your interaction with the spreadsheet will be through the GPM Calculator page and it is the most involved page so we will discuss it last.

Figure 1. The main GPM Calculator page of the Avocado GPM Calculator spreadsheet with the three additional pages shown in the tabs at the bottom of the page.

Spacing Chart. This page of the spreadsheet has no user modifiable inputs **(Figure 2)**. The purpose of this page is to provide growers with the "trees per acre" variable they will need when inputting data on the GPM Calculator page.



Tree Spacing Table — Number of Trees Per Acre

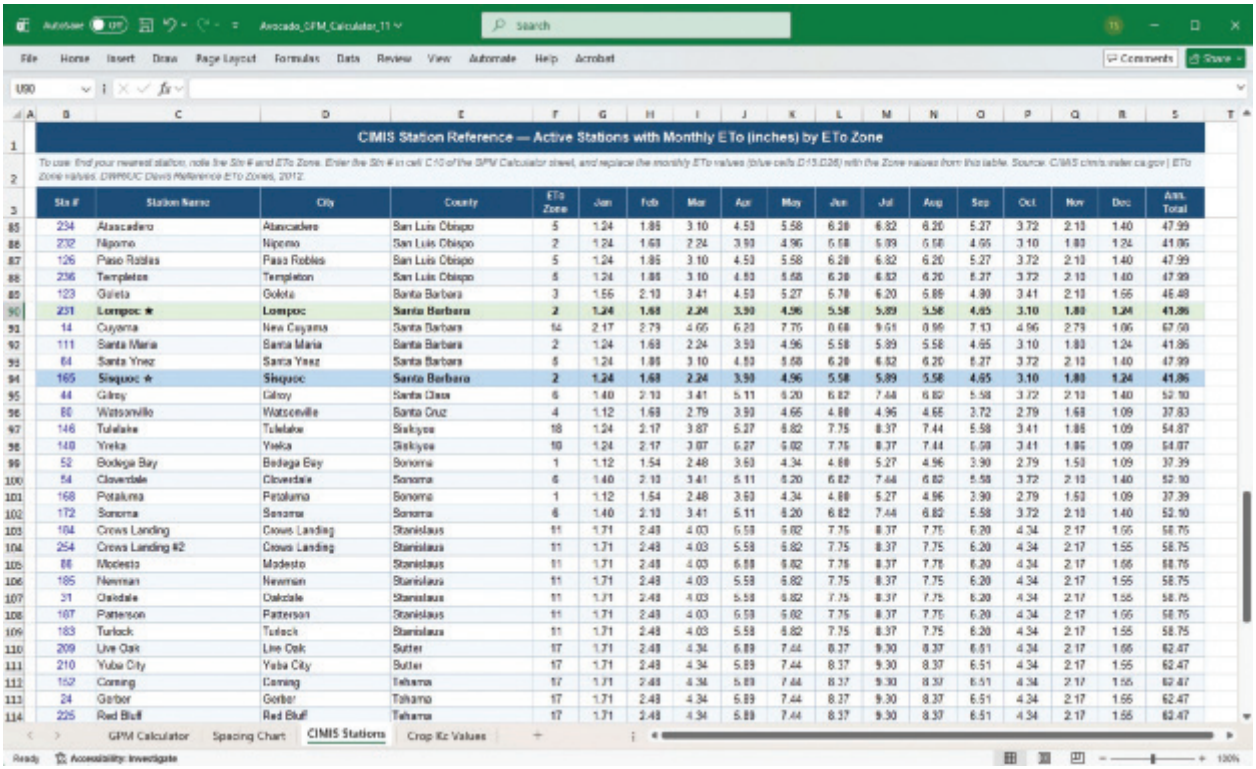
Source: Tree Spacing Table, California Avocado Commission. Row = one dimension (ft), Column = other dimension (ft). Note: spacings do not allow for special drive roads. To use: find your spacing, read trees/acre, enter in GPM Calculator cell C5.

Spacing (ft × ft)	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
6 ft	1,210	1,037	908	807	726	660	605	558	519	484	454	427	403	382	363	346	330	316	303
7 ft	1,037	889	778	691	622	566	519	479	444	415	389	366	346	328	311	296	283	271	259
8 ft	908	778	681	605	545	495	455	419	393	364	341	320	303	287	272	260	248	237	227
9 ft	807	691	605	538	484	440	404	373	346	323	303	285	269	255	242	230	220	210	202
10 ft	726	622	545	484	436	396	364	336	311	291	272	256	242	229	218	208	198	189	182
11 ft	660	566	495	440	396	360	330	305	283	264	248	233	220	208	198	189	180	172	165
12 ft	605	519	454	403	363	330	303	279	260	242	227	214	202	193	182	173	165	158	151
13 ft	558	479	419	372	335	305	279	258	240	224	210	197	186	177	168	160	152	146	140
14 ft	519	444	389	346	311	283	260	240	222	208	195	183	173	164	156	148	141	135	130
15 ft	484	415	363	323	290	264	242	224	208	194	182	171	162	153	145	138	132	127	121
16 ft	454	389	340	303	272	248	227	210	195	182	170	160	151	143	136	130	124	118	114
17 ft	427	366	320	285	256	233	214	197	183	171	160	151	142	135	128	122	116	111	107
18 ft	403	346	303	269	242	220	202	186	173	161	151	142	134	127	121	115	110	105	101
19 ft	382	328	287	255	229	208	191	177	164	153	143	135	128	121	115	109	104	99	95
20 ft	363	311	272	242	218	198	182	168	156	145	136	128	121	115	109	104	99	95	91

Green cell = 20×20 ft (109 trees/ac) — standard Hass spacing | Blue diagonal = square spacings | To use in GPM Calculator: find your spacing, note the trees/acre value, enter it in cell C5 on the GPM Calculator sheet.

Figure 2. The Spacing Chart page of the calculator. There are no user modifiable options on this page.

CIMIS Stations. Like the Spacing Chart page, this page does not have any user inputs **(Figure 3)**. It is used to complete the required inputs on the GPM Calculator page.



CIMIS Station Reference — Active Stations with Monthly ETo (inches) by ETo Zone

To use: find your nearest station, note the Sta # and ETo Zone. Enter the Sta # in cell C10 of the GPM Calculator sheet, and replace the monthly ETo values (blue cells D13:D26) with the Zone values from this table. Source: CIMIS cimis.water.ca.gov | ETo Zone values: DWR/UC Davis Reference ETo Zones, 2012.

Sta #	Station Name	City	County	ETo Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann. Total
234	Atascadero	Atascadero	San Luis Obispo	5	1.24	1.86	3.10	4.53	5.58	6.20	6.82	6.20	5.27	3.72	2.10	1.40	47.99
232	Nipomo	Nipomo	San Luis Obispo	2	1.24	1.63	2.24	3.90	4.96	5.58	5.89	5.58	4.65	3.10	1.80	1.24	41.86
126	Paso Robles	Paso Robles	San Luis Obispo	5	1.24	1.86	3.10	4.53	5.58	6.20	6.82	6.20	5.27	3.72	2.10	1.40	47.99
236	Templeton	Templeton	San Luis Obispo	5	1.24	1.86	3.10	4.53	5.58	6.20	6.82	6.20	5.27	3.72	2.10	1.40	47.99
123	Goleta	Goleta	Santa Barbara	3	1.55	2.10	3.41	4.53	5.27	6.20	6.20	5.89	4.80	3.41	2.10	1.55	46.48
231	Lompoc ★	Lompoc	Santa Barbara	2	1.24	1.63	2.24	3.90	4.96	5.58	5.89	5.58	4.65	3.10	1.80	1.24	41.86
14	Cuyama	New Cuyama	Santa Barbara	14	2.17	2.79	4.65	6.20	7.75	8.68	9.61	8.99	7.13	4.96	2.79	1.86	67.69
111	Santa Maria	Santa Maria	Santa Barbara	2	1.24	1.63	2.24	3.90	4.96	5.58	5.89	5.58	4.65	3.10	1.80	1.24	41.86
64	Santa Ynez	Santa Ynez	Santa Barbara	5	1.24	1.86	3.10	4.53	5.58	6.20	6.82	6.20	5.27	3.72	2.10	1.40	47.99
165	Sisquoc ★	Sisquoc	Santa Barbara	2	1.24	1.63	2.24	3.90	4.96	5.58	5.89	5.58	4.65	3.10	1.80	1.24	41.86
44	Gilroy	Gilroy	Santa Clara	6	1.40	2.10	3.41	5.11	6.20	6.82	7.44	6.82	5.58	3.72	2.10	1.40	52.10
80	Watsonville	Watsonville	Santa Cruz	4	1.12	1.63	2.79	3.90	4.65	4.80	4.96	4.65	3.72	2.79	1.63	1.09	37.83
146	Tulelake	Tulelake	Siskiyou	18	1.24	2.17	3.87	5.27	6.82	7.75	8.37	7.44	5.58	3.41	1.86	1.09	54.87
148	Yreka	Yreka	Siskiyou	18	1.24	2.17	3.87	5.27	6.82	7.75	8.37	7.44	5.58	3.41	1.86	1.09	54.87
52	Bodega Bay	Bodega Bay	Sonoma	1	1.12	1.54	2.48	3.63	4.34	4.80	5.27	4.96	3.90	2.79	1.53	1.09	37.39
54	Cloverdale	Cloverdale	Sonoma	6	1.40	2.10	3.41	5.11	6.20	6.82	7.44	6.82	5.58	3.72	2.10	1.40	52.10
168	Petaluma	Petaluma	Sonoma	1	1.12	1.54	2.48	3.63	4.34	4.80	5.27	4.96	3.90	2.79	1.53	1.09	37.39
172	Sonoma	Sonoma	Sonoma	6	1.40	2.10	3.41	5.11	6.20	6.82	7.44	6.82	5.58	3.72	2.10	1.40	52.10
184	Crows Landing	Crows Landing	Stanislaus	11	1.71	2.48	4.03	5.58	6.82	7.75	8.37	7.75	6.20	4.34	2.17	1.55	58.75
254	Crows Landing #2	Crows Landing	Stanislaus	11	1.71	2.48	4.03	5.58	6.82	7.75	8.37	7.75	6.20	4.34	2.17	1.55	58.75
88	Modesto	Modesto	Stanislaus	11	1.71	2.48	4.03	5.58	6.82	7.75	8.37	7.75	6.20	4.34	2.17	1.55	58.75
185	Newman	Newman	Stanislaus	11	1.71	2.48	4.03	5.58	6.82	7.75	8.37	7.75	6.20	4.34	2.17	1.55	58.75
31	Oakdale	Oakdale	Stanislaus	11	1.71	2.48	4.03	5.58	6.82	7.75	8.37	7.75	6.20	4.34	2.17	1.55	58.75
167	Patterson	Patterson	Stanislaus	11	1.71	2.48	4.03	5.58	6.82	7.75	8.37	7.75	6.20	4.34	2.17	1.55	58.75
183	Turlock	Turlock	Stanislaus	11	1.71	2.48	4.03	5.58	6.82	7.75	8.37	7.75	6.20	4.34	2.17	1.55	58.75
209	Live Oak	Live Oak	Sutter	17	1.71	2.48	4.34	6.89	7.44	8.37	9.30	8.37	6.51	4.34	2.17	1.55	62.47
210	Yuba City	Yuba City	Sutter	17	1.71	2.48	4.34	6.89	7.44	8.37	9.30	8.37	6.51	4.34	2.17	1.55	62.47
162	Corning	Corning	Tehama	17	1.71	2.48	4.34	6.89	7.44	8.37	9.30	8.37	6.51	4.34	2.17	1.55	62.47
24	Gerber	Gerber	Tehama	17	1.71	2.48	4.34	6.89	7.44	8.37	9.30	8.37	6.51	4.34	2.17	1.55	62.47
225	Red Bluff	Red Bluff	Tehama	17	1.71	2.48	4.34	6.89	7.44	8.37	9.30	8.37	6.51	4.34	2.17	1.55	62.47

Figure 3. The CIMIS Stations page of the calculator. Scroll through the list of stations to find the one nearest to you or that best approximates the conditions at your location. You will enter the station number on the GPM Calculator page.

Crop K_c Values. To fully understand what K_c values are, we encourage you to read, "Re-evaluating Avocado Water Needs: What is the True Avocado Crop Coefficient?" in the Spring 2026 issue of *From the Grove*. Briefly, a K_c or crop coefficient is a number used to adjust a reference evapotranspiration (ET_o) value, which is usually based on a well-watered grass, to the evapotranspiration of our crop (ET_c). For example, if the ET_o is 1 inch for a seven-day period and the K_c for our crop is 0.5, our ET_c is 0.5 inch. In other words, we need to run our irrigation system to supply 0.5 inches of water per unit area (e.g., an acre).

K_c values for avocados in California have never been very good, until recently. Dr. Ali Montazar, UC Irrigation and Water Management Advisor, recently completed a multi-year project to determine the actual K_c values for Hass avocados in California (unfortunately we do not currently have accurate K_c values for other varieties). These K_c values are shown on the Crop K_c Values page of the spreadsheet along with the average values from the study and the option to insert user-defined values **(row 11; Figure 4)**.

Why would you want to enter user-defined K_c values? Because Dr. Montazar's study could not determine the actual K_c value for every avocado grove, some interpolation of his data may be required. For example, Tim suggested to David that a piece of property he was looking at may best be represented by an average of the K_c values for sites AV3 and AV5. This average is shown by default in row 11 when you open the spreadsheet. Row 12 of the Crop K_c Values page provides some additional information to consider how to blend Dr. Montazar's data to suit your grove.

This page also provides K_c values for many other common fruit and vegetable crops in California, along with source references, should you wish to use this calculator for something other than avocados. However, as designed, the spreadsheet will only provide good calculations for tree crops without modifications.

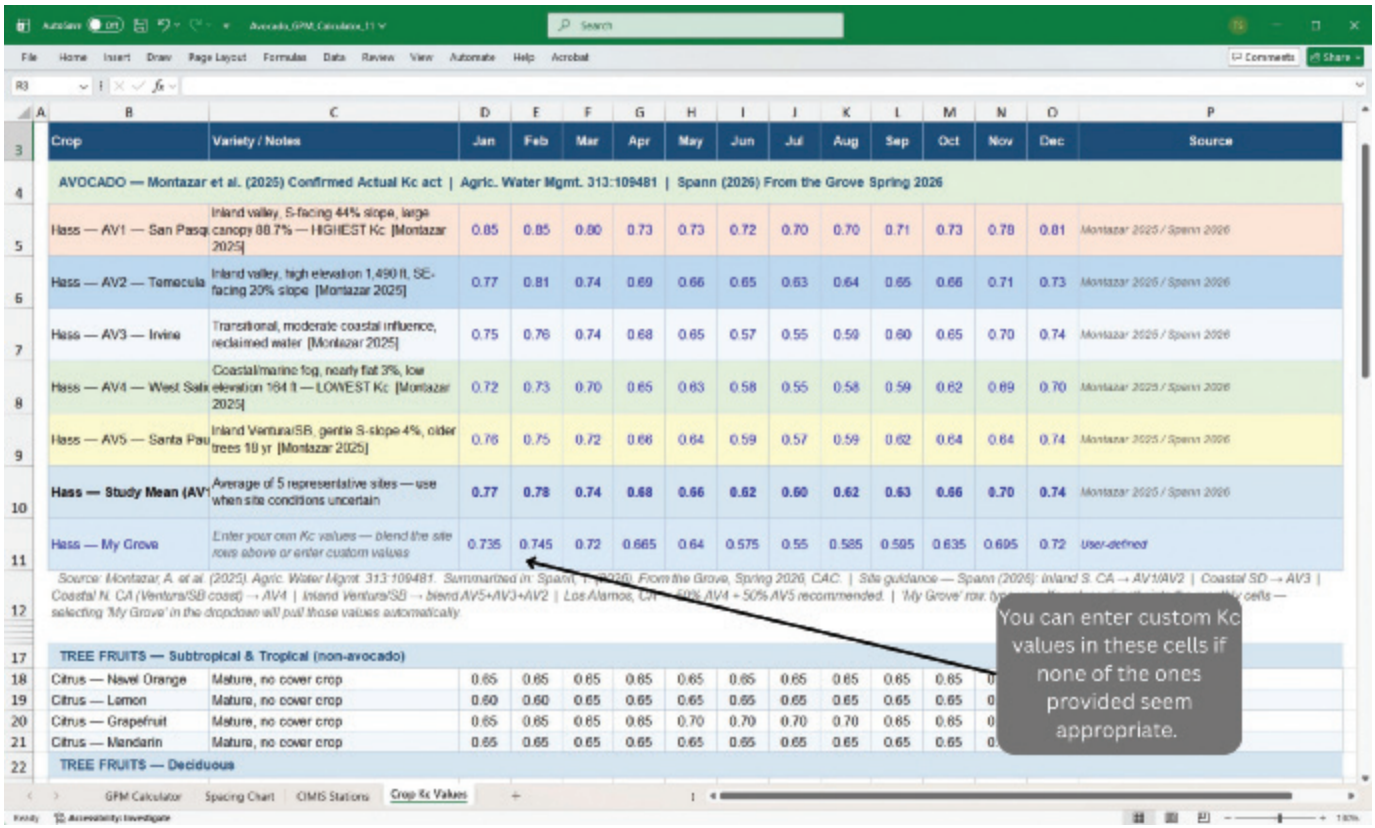


Figure 4. The Crop K_c Values page of the calculator. On the GPM Calculator page you will select one of the five established sets of K_c values, the average of the five sets or custom K_c values that you enter here.

GPM Calculator. This is the page of the calculator that you will interact with most and it is the page the spreadsheet will open to by default. This page is divided into five sections, and we'll go through each one.

A. Your Grove Inputs: In this section you will change the values in **BLUE**. The first input is CIMIS Station number. This can be found on the CIMIS Stations page. Select the CIMIS station nearest to your grove location or the station that you know from experience best matches your grove location. The Station/County/Zone cell will be automatically populated when you enter your CIMIS Station number.

Next enter the number of trees you have or are planning to plant followed by the trees per acre, which is obtained from the Spacing Chart page.

Next enter your irrigation system's distribution uniformity (DU). Don't know your system's DU? We won't judge. Visit the Cal Poly Irrigation Training and Research Center's website for some helpful information about what DU is and how to measure it: https://www.itrc.org/projects/evals.htm.

The next value you need to enter is your leaching fraction. This should be based on a water quality analysis of your water source. Your testing laboratory will be able to provide you with a leaching fraction estimate.

The next two items you need to enter are based on your level of risk tolerance. How many hours every day do you want to run your well and how many days per week? As mentioned in the Spring 2024 article, all equipment eventually fails. If you plan to run your irrigation all day every day there's no time left for the inevitable failure, which means something is going to go without water when that breakdown happens. Decide how many days per week you want to run your system and how many hours each day you want it to run and enter those values in cells C10 and C11.

Lastly, select which of the Crop K_c Values you wish to use from the drop-down menu. The drop-down menu is accessed by clicking the small down arrow in the lower right corner of cell C12. When you make your selection, the K_c values in Section C will be automatically populated.

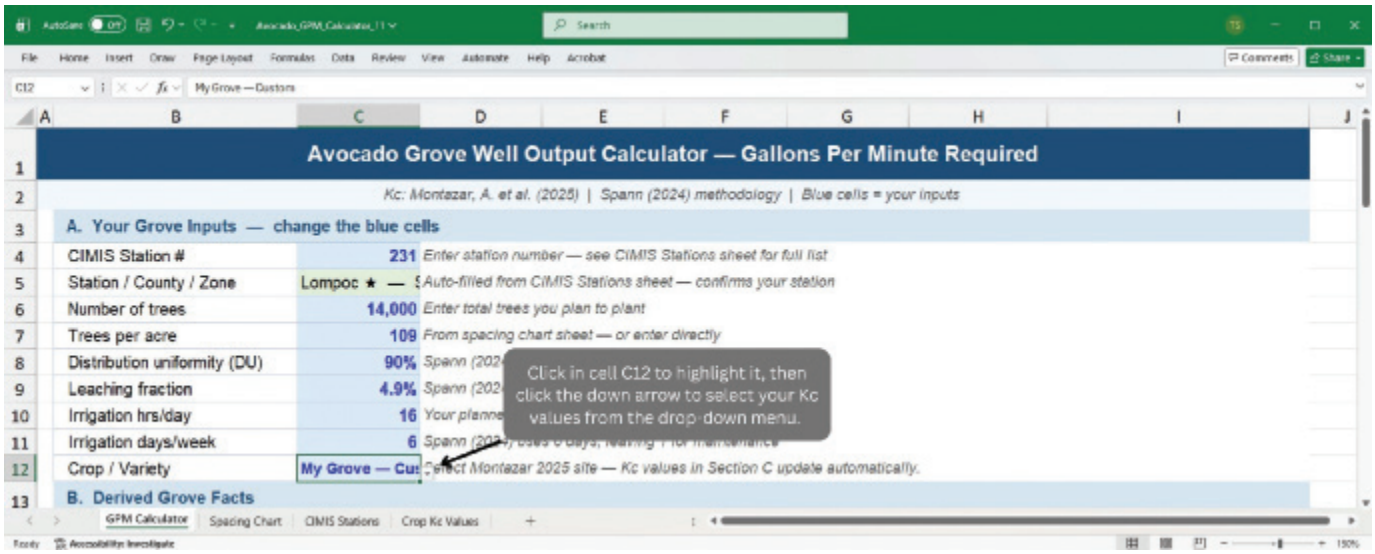
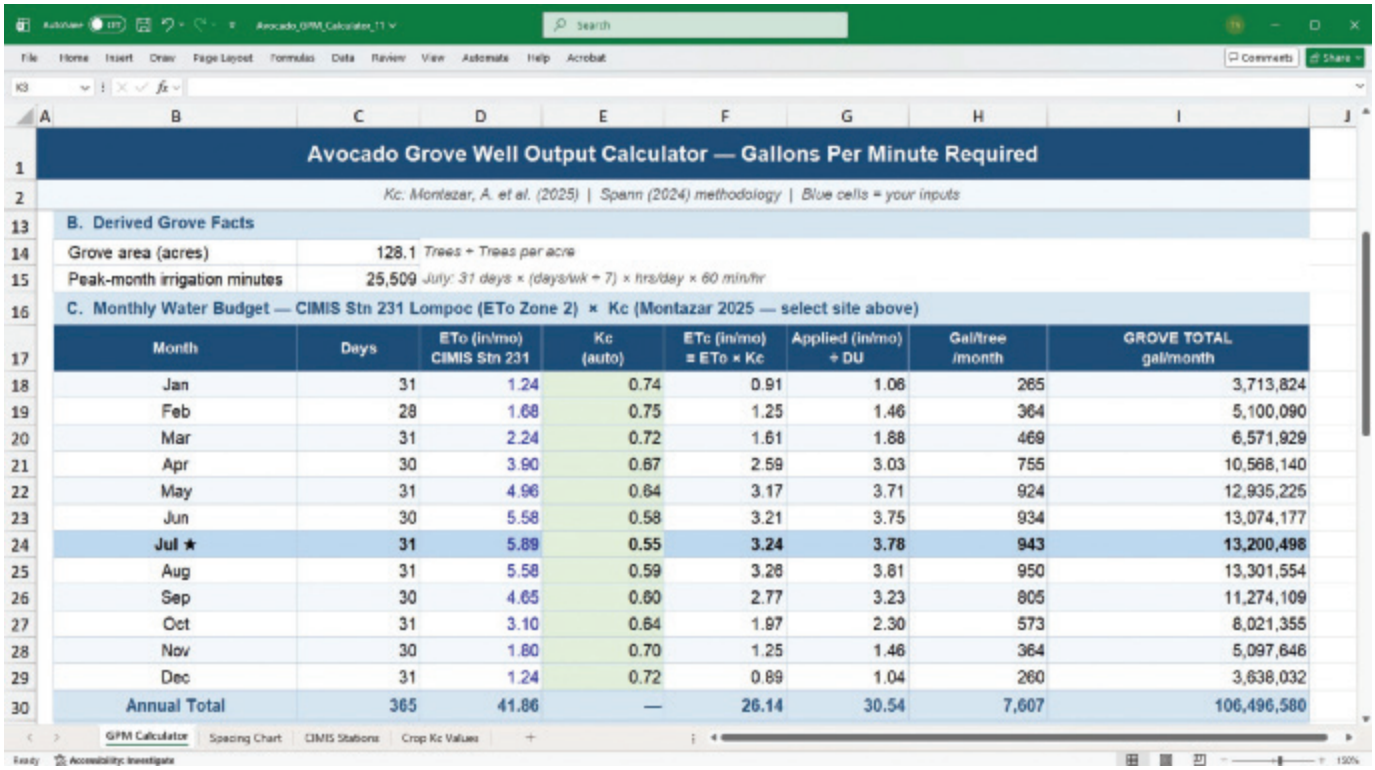


Figure 5.Section A of the GPM Calculator page is where you enter the details about your grove.

B. Derived Grove Facts: There are no user modifiable values in this section. The grove area and peak-month irrigation minutes values are automatically calculated based on the inputs in Section A.

C. Monthly Water Budget: In this section you will again change the values in **BLUE**, which refer to the ET_o for the CIMIS Station you selected in Section A. You can copy and paste these values from the CIMIS Stations page to the appropriate cells on the GPM Calculator page.



Avocado Grove Well Output Calculator — Gallons Per Minute Required

Kc: Montazar, A. et al. (2025) | Spann (2024) methodology | Blue cells = your inputs

B. Derived Grove Facts

Grove area (acres)	128.1	*Trees ÷ Trees per acre*
Peak-month irrigation minutes	25,509	*July: 31 days × (days/wk ÷ 7) × hrs/day × 60 min/hr*

C. Monthly Water Budget — CIMIS Stn 231 Lompoc (ETo Zone 2) × Kc (Montazar 2025 — select site above)

Month	Days	ETo (in/mo) CIMIS Stn 231	Kc (auto)	ETc (in/mo) = ETo × Kc	Applied (in/mo) ÷ DU	Gal/tree /month	GROVE TOTAL gal/month
Jan	31	1.24	0.74	0.91	1.06	265	3,713,824
Feb	28	1.68	0.75	1.25	1.46	364	5,100,090
Mar	31	2.24	0.72	1.61	1.88	469	6,571,929
Apr	30	3.90	0.67	2.59	3.03	755	10,568,140
May	31	4.96	0.64	3.17	3.71	924	12,935,225
Jun	30	5.58	0.58	3.21	3.75	934	13,074,177
Jul ★	**31**	**5.89**	**0.55**	**3.24**	**3.78**	**943**	**13,200,498**
Aug	31	5.58	0.59	3.26	3.81	950	13,301,554
Sep	30	4.65	0.60	2.77	3.23	805	11,274,109
Oct	31	3.10	0.64	1.97	2.30	573	8,021,355
Nov	30	1.80	0.70	1.25	1.46	364	5,097,646
Dec	31	1.24	0.72	0.89	1.04	260	3,638,032
Annual Total	365	41.86	—	26.14	30.54	7,607	106,496,580

Figure 6. Section B of the GPM Calculator page shows calculated values based on the information you entered in Section A. Section C of the GPM Calculator page is where you will enter the reference evapotranspiration (ET_o) values for the CIMIS Station entered in Section A.

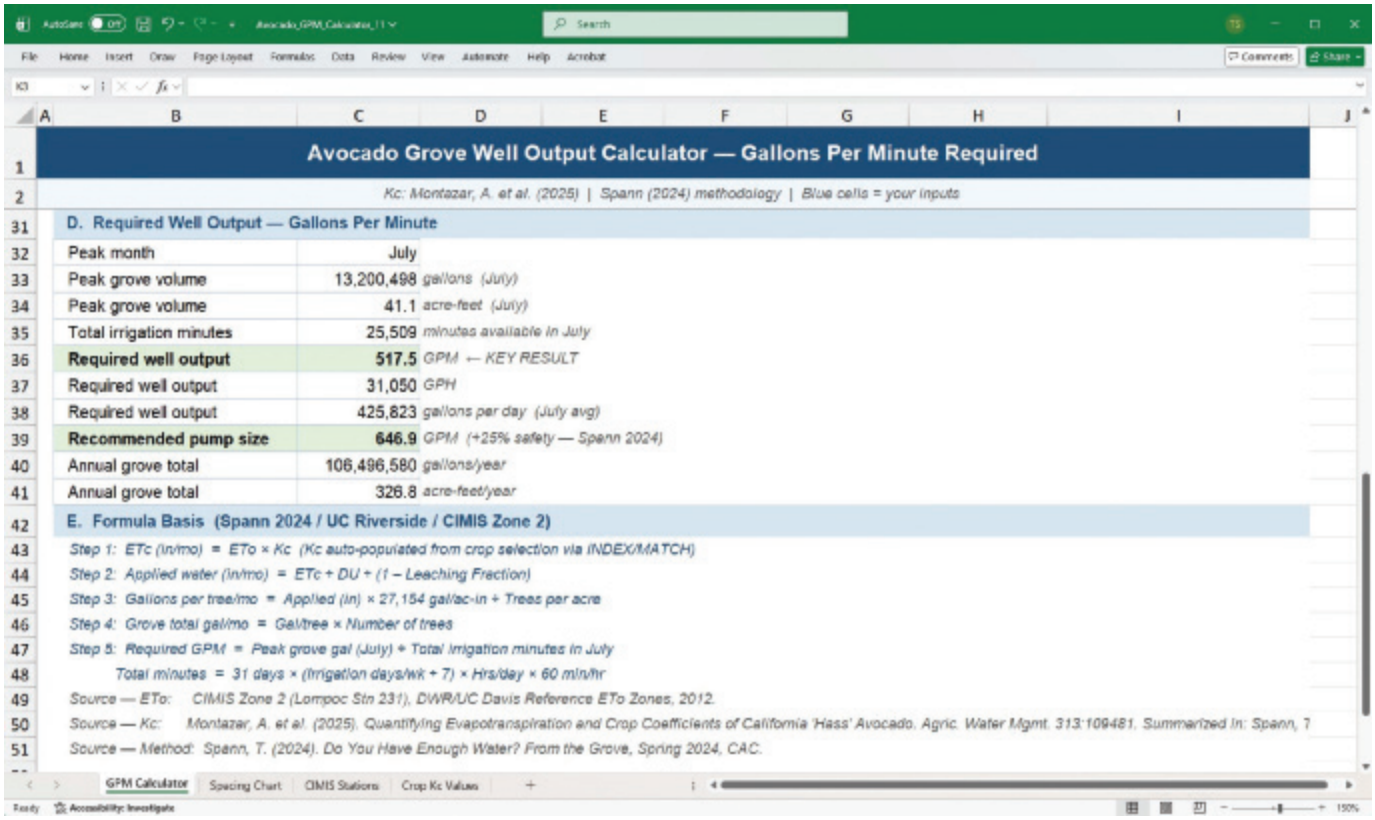
D. Required Well Output: Again, this section has no user modifiable values but is the product of the data entered into in the previous sections, i.e., it's the answer! This section tells you the peak month for water demand, the peak volume of water in gallons and acre-feet for that month, and the number of available irrigation minutes for that month based on your irrigation hours per day and days per week in Section A.

The next values provided are the well output in gallons per minute (GPM), gallons per hour (GPH) and gallons per day for the peak irrigation month. You are then provided with a recommended pump capacity in GPM. This value has a built in 25% buffer. That is, if your maximum required well output came out to 400 GPM the spreadsheet would recommend a pump capacity of 500 GPM. Again, you never want any of your equipment to be working at maximum capacity. You could adjust this value if you want a larger or smaller safety margin.

The last two values are the estimated total water need for the grove in gallons per year and acre-feet per year.

E. Formula Basis: This section provides the basic formulas that were used to make all the calculations and some of the sources used to build the spreadsheet.

We hope that you find this tool helpful. If you use it and have any questions, please reach out to Tim at tim@spannag.com. If you have ideas for other tools like this that may be helpful, please let us know and we'll see what Claude can whip up.



Avocado Grove Well Output Calculator — Gallons Per Minute Required

Kc: Montazar, A. et al. (2025) | Spann (2024) methodology | Blue cells = your inputs

D. Required Well Output — Gallons Per Minute

Peak month	July	
Peak grove volume	13,200,498	*gallons (July)*
Peak grove volume	41.1	*acre-feet (July)*
Total irrigation minutes	25,509	*minutes available in July*
Required well output	**517.5**	*GPM ← KEY RESULT*
Required well output	31,050	*GPH*
Required well output	425,823	*gallons per day (July avg)*
Recommended pump size	**646.9**	*GPM (+25% safety — Spann 2024)*
Annual grove total	106,496,580	*gallons/year*
Annual grove total	326.8	*acre-feet/year*

E. Formula Basis (Spann 2024 / UC Riverside / CIMIS Zone 2)

Step 1: ETc (in/mo) = ETo × Kc (Kc auto-populated from crop selection via INDEX/MATCH)

Step 2: Applied water (in/mo) = ETc ÷ DU ÷ (1 − Leaching Fraction)

Step 3: Gallons per tree/mo = Applied (in) × 27,154 gal/ac-in ÷ Trees per acre

Step 4: Grove total gal/mo = Gal/tree × Number of trees

Step 5: Required GPM = Peak grove gal (July) ÷ Total irrigation minutes in July

Total minutes = 31 days × (Irrigation days/wk ÷ 7) × Hrs/day × 60 min/hr

Source — ETo: CIMIS Zone 2 (Lompoc Stn 231), DWR/UC Davis Reference ETo Zones, 2012.

Source — Kc: Montazar, A. et al. (2025). Quantifying Evapotranspiration and Crop Coefficients of California 'Hass' Avocado. Agric. Water Mgmt. 313:109481. Summarized in: Spann, T

Source — Method: Spann, T. (2024). Do You Have Enough Water? From the Grove, Spring 2024, CAC.

Figure 7. Section D of the GPM Calculator page shows the results of the calculations and Section E shows the equations used to make the calculations and the sources for the information used to develop the calculator.